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(54) Multiple level undo/redo mechanism.

(57) A multiple-level undo/redo mechanism is provided in an operating system and is available to application programs run on the operating system. The operating system provides a mechanism for keeping a log of user commands and providing a cursor to a position within the log. Each command may be encapsulated into an object that supports an interface for performing undo/redo operations. Similarly, the log may be encapsulated into an object that supports operations that facilitate a multiple-level undo/redo. A user may perform a single undo/redo operation, multiple successive undo/redo operations or complete undo/redo operations.

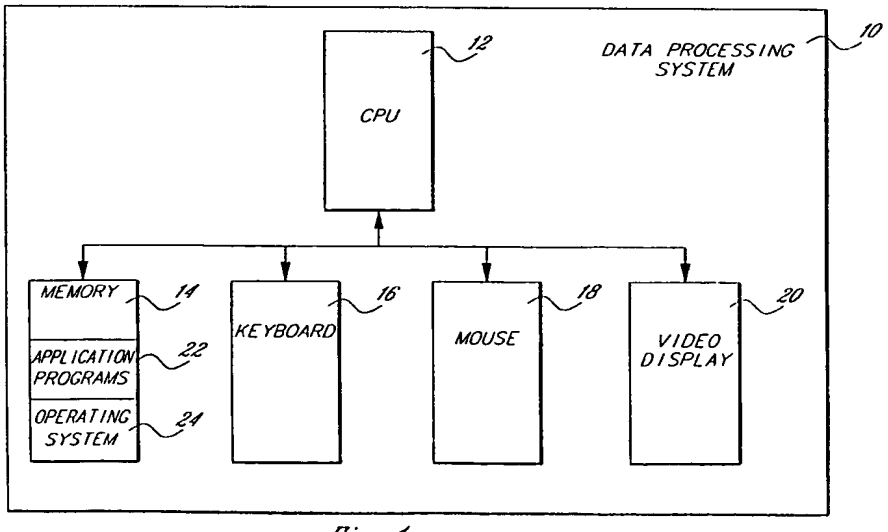

Fig. 1

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tivated (see Figure 3b). A similar context menu 57 (Figure 3c) is provided for the redo button. The context menus 55 (Figure 3b) and 57 (Figure 3c) provide two options: "Last Applied" and "All The Way." These options cause either only a single last applied command to be undone/redone or the commands to be undone/redone.

The four operations provided by the multiple-level undo/redo mechanism of the preferred embodiment of the present invention are perhaps best explained by way of example. As such, examples will be provided below along with the steps performed by the preferred embodiment for each of the respective four operation types.

Figure 4a is a flowchart illustrating the steps performed by the preferred embodiment of the present invention when a user enters a new command. Figure 4a will be described in conjunction with the diagram of Figure 4b. Figure 4b depicts an example of the list 30 of command element objects. Initially, a user enters a command (step 52 in Figure 4a). In the example of Figure 4b, the list 30 is initially empty. Suppose that the user then enters command "a". The multiple level undo/redo mechanism of the preferred embodiment then checks whether there are any commands on the list before the cursor 32 (step 54 in Figure 4a). If there are no commands on the list before the cursor 32, such as in the case shown in Figure 4b, the command is added to the front of the list 30 (step 58 in Figure 4a), and the cursor is moved to point to the front of the list (step 60). Thus, as shown in Figure 4b, after command "a" is entered, an entry 64 (i.e., an entry for a command element object for command "a") is added to the front of the list 30 and the cursor 32 is moved to point to entry 64. Suppose that the user now enters another command "b", (hence, repeating step 52 of Figure 4a). Steps 54, 58 and 60 of Figure 4a are then repeated so that an entry 66 (Figure 4b) is added to the front of the list 30 before the entry 64 for command "a". Cursor 32 is updated to point to entry 66 for command "b".

In the above-described fashion, the list 30 of command element objects is built. In terms of the object model described above, each time a user enters a command, an instance of a command element object 40 (Figure 2) is created; the new command element object is appended to the front of the list; and the cursor position is updated.

If in step 54 of Figure 4a it is determined that there are commands on the list 30 that are situated before the cursor 32, all the commands on the list that are before the cursor are deleted (step 56 in Figure 4a). Figure 4c shows an example of such a deletion. Suppose that initially list 30 of command log elements includes entries 68, 70 and 72 for commands "a", "b" and "c", respectively, as shown in Figure 4c. The cursor 32 points to entry 70 for command "b". Subsequently, a user enters command "d". In step 54 of Figure 4a, it is determined that entry 72 for command "c" is positioned before the cursor on list 30. Hence, entry 72 is deleted in step 56 of Figure 4a. Further, an entry 73 for command "d" is added to the front of the list 30 (see step 58 in Figure 4a), and the cursor 32 (Figure 4c) is updated to point to entry 73 (see step 60 in Figure 4a).

Once a user has built a list 30 of command element objects, such as described above, the user may execute an undo command. Figure 5a is a flowchart of the steps performed when an undo command is requested. Figure 5b is a diagram illustrating the state of the list 30 of command element objects after multiple undo commands are performed on the list. The steps of Figure 5a will be described in conjunction with the diagram of Figure 5b. Initially, a user requests an undo operation by activating the undo button 51 (Figure 3b) provided in the user interface. As was described above, a context menu 55 is displayed after the button 51 is activated and the context menu provides the user with the option of undoing only the most recent command (i.e., the "Last Applied" option). Suppose that the user selects the "Last Applied" option on the context menu 55 (step 74 in Figure 5a). The command pointed to by the cursor 32 is undone by executing code 50a (Figure 2) that is provided in the command element object (step 76) for undoing the command. In addition, the cursor 32 is decremented to point to the next successive entry on the list 30 of command element objects. To perform multiple-level undo operations, the user activates the undo button 51 multiple times to repeat the above-described steps.

Figure 5b shows an example of successive undo operations. Suppose that initially a list of command element objects includes entries 80, 82 and 84 for commands "a", "b" and "c", respectively. Further suppose that cursor 32 points to entry 84. When a user subsequently requests an undo operation, command "c" is undone and the cursor 32 is moved to point to entry 82 for command "b". If the user makes an additional undo operation request, command "b" is also undone, and the cursor is moved to point to entry 80 for command "a".

A user may also request a single redo operation. Figure 6a is a flowchart of the steps performed for a single redo operation of a most recently undone command. The process begins with a user requesting a redo operation of the most recently undone command. The user activates the redo button 53 (Figure 3c) from the user interface and then chooses the "Last Applied" option from the context menu 57 (step 86 in Figure 6a). The

command immediately in front of the current cursor position on list 30 is then performed (step 88), and the cursor is incremented (step 90). In terms of the object model discussed above with reference to Figure 2, the redo code 50b is executed on the command element object 40 that was most recently undone. To perform multiple-level redo operations, the user activates the redo button 53 multiple times to repeat the steps of Figure 6a.

Figure 6b shows an example of the effect of a redo command. Initially, a list 30 includes entries 92 and 94 for commands "a" and "b", respectively. Cursor 32 points to entry 92 for command "a". When the user enters a redo command, command "b" is again performed and the cursor 32 is incremented to point to entry 94 for command "b".

The user has the additional option of undoing all commands on the list 30 of command element objects. Figure 7a is a flowchart of the steps performed for a undo "All the Way" operation. Initially, a user requests that an undo "All the Way" operation be performed (Step 96 in Figure 7a). The user requests such a command by activating the undo button 51 (Figure 3b) and then selecting the "All the Way" option on the context menu 55. All user commands from the current command to the initial command are reversed (step 98 in Figure 7a). In addition, the cursor is moved to point to before the initial command on list 30 (step 100).

Figure 7b shows an example of the effect of an undo "All the Way" operation. Initially, a list 30 of command element objects 30 includes entries 102, 104 and 106 for commands "a", "b" and "c", respectively. The cursor 32 points to entry 106 for command "c". After the user has requested the undo "All the Way" operation, commands "c", "b" and "a" are sequentially undone, and the cursor 32 is decremented to point to before the first entry on the list 30.

A user may, likewise, request that the redo operation be performed "All the Way" to redo all of the commands on the list that are situated in front of the current cursor position. Figure 8a is a flowchart of the steps performed for such an operation. Initially, the user requests that the redo "All the Way" operation be performed (step 108 in Figure 8a). As with the other operations, the user selects the operation through the user interface. In particular, the user activates the redo button 53 and then selects the "All the Way" option from the context menu 57 (Figure 3c). After the selection has been made, the commands that are positioned in front of the cursor 32 on the list are performed (step 110 in Figure 8a). In addition, the cursor position is incremented to point to the front of the list (step 112).

Figure 8b shows an example that illustrates the effect of the redo "All the Way" operation. Initially, a list 30 of command element objects includes entries 114, 116 and 118 for commands "a", "b" and "c", respectively. The cursor 32 points to entry 114 for command "a." After the redo "All the Way" operation is performed, commands "b" and "c" have been sequentially executed, and the cursor position is incremented to point to entry 118 for command "c".

While the present invention has been described with reference to a preferred embodiment thereof, those skilled in the art will, nevertheless, appreciate that various changes in form and detail may be made without departing from the present invention as defined by the appended claims.

Claims

1. In a data processing system having memory means and at least one processor that is responsive to user commands, a method comprising the steps of:
   (a) storing a log of user commands that were executed by the processor in the memory means;
   (b) undoing a first user command stored in the log so as to reverse an effect of the first user command; and
   (c) undoing a next user command stored in the log so as to reverse an effect of the next user command.

2. The method as recited in claim 1 wherein the step of storing a log of user commands further comprises the steps of:
   (i) storing each user command that was executed by the processor as an object on a list in the memory means;
   (ii) linking adjacent objects on the list; and
   (iii) storing a cursor that points to an object for one of the user commands on the list that was last executed by the processor.

3. The method as recited in claim 1 wherein the step of storing a log of user commands further comprises the step of storing the user commands sequentially in the log as the user commands are executed by the processor.

4. The method as recited in claim 1 further comprising the step of undoing all of the user commands stored in the log to reverse effects of all of the user commands stored in the log.

5. The method as recited in claim 1 further comprising the step of again executing the next command.

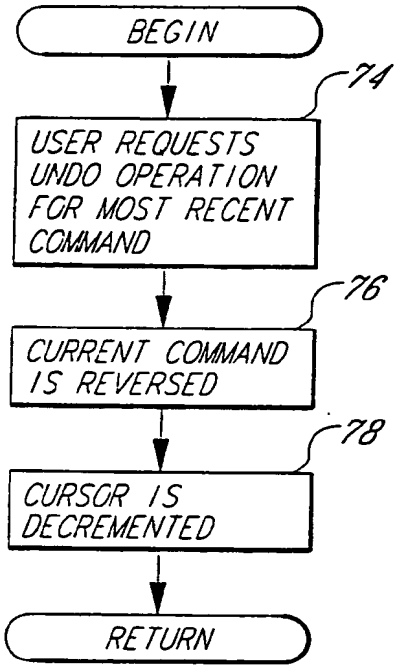

Fig. 5a

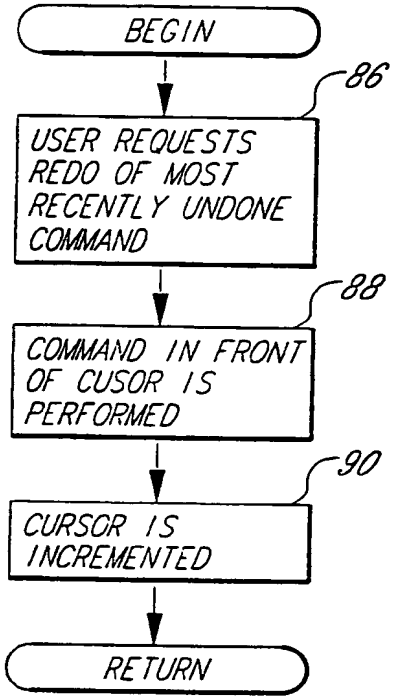

Fig. 6a

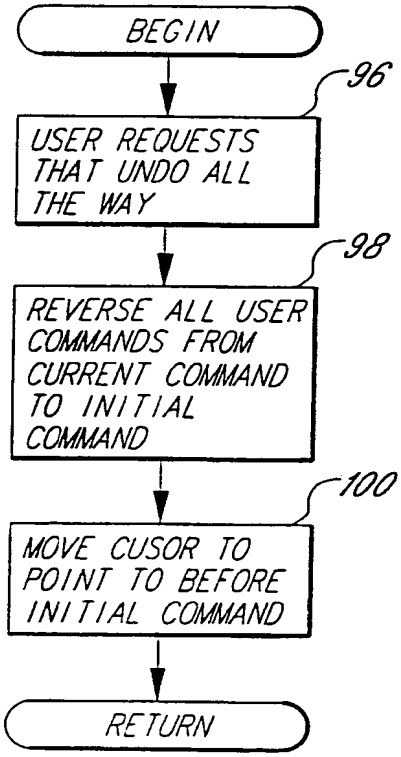

Fig. 7a

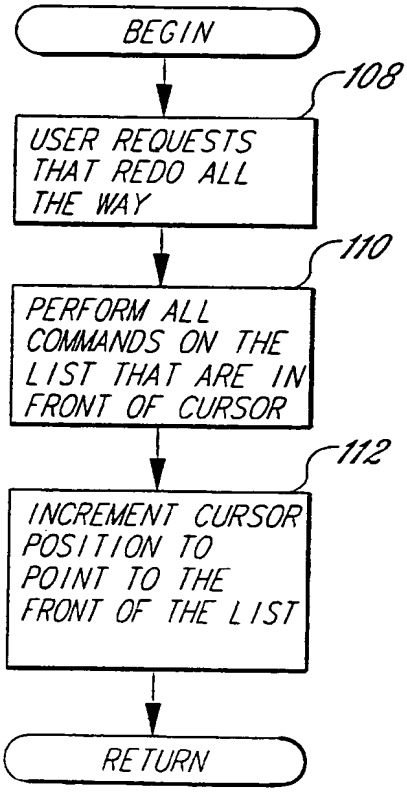

Fig. 8a

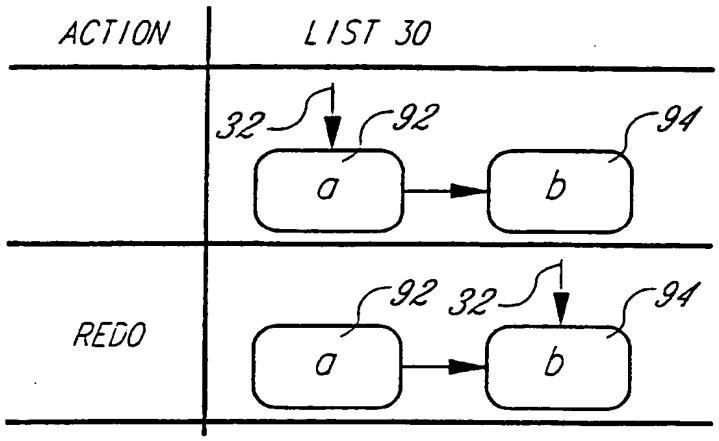

Fig. 6b

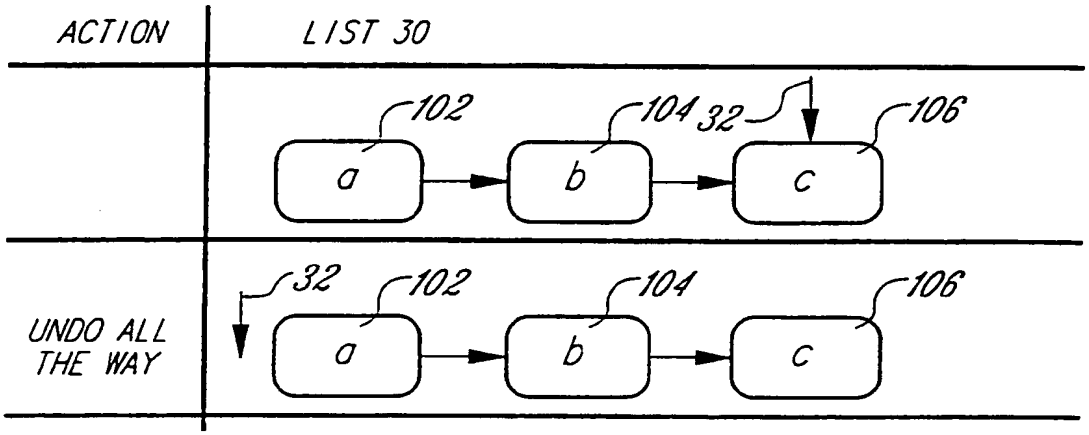

Fig. 7b

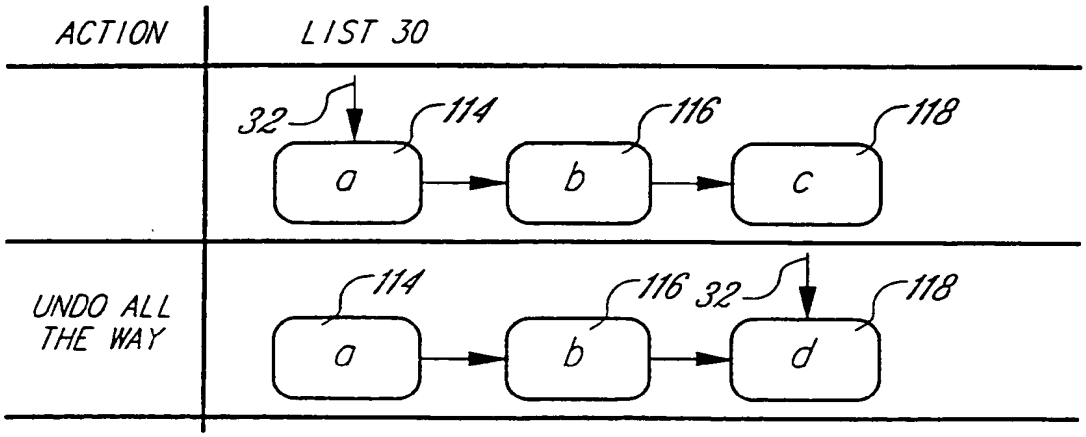

Fig. 8b

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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 6131

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	IEEE SOFTWARE vol. 1, no. 4 , October 1984 , LOS ALAMITOS US pages 39 - 52 VITTER 'US&R: A new framework for redoing' * page 41, left column, line 1 - page 48, right column, line 4 * ---	1-18	G06F3/033 G06F9/44
A	4TH ANNUAL SYMPOSIUM ON USER INTERFACE SOFTWARE AND TECHNOLOGY 11 November 1991 , USA pages 107 - 115 WANG ET AL 'An event-object recovery model for object-oriented user interfaces.' * page 107, right column, line 3 - line 37 * * page 109, right column, line 36 - page 110, right column, line 43 * -----	1-18	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 July 1994	Brandt, J

CATEGORY OF CITED DOCUMENTS

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